EFFICIENCY OF REVERSE-JET FILTERS ON URANIUM REFINING OPERATIONS

by

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INTRODUCTION

The efficiency of reverse-jet filters is a very interesting subject and is one on which it is difficult to gather reliable data on applications other than radioactive. Added to this complexity is the fact that for the most industrial applications, it makes little difference whether the collection efficiency is 99.9% or 99.99%, and therefore little efficiency data is forthcoming from users other than those handling radioactive materials.

In considering the data presented here, it should be kept in mind that the plant from which it originates is primarily a high-volume production unit, not a laboratory or research unit. Although the control of dust in the plant and the proper and efficient collection of that dust are of prime importance, there is little "research time" available for investigations on the fine points of control systems that are doing a satisfactory job. Thus investigations which were started, or begun on a pilot basis, sometimes have not yet been carried through to completion, and one finds places in the data where there are more questions than there are answers. Nevertheless, much data gathered here is invaluable because it represents actual production operation conditions, and could not be duplicated on a research basis without excessive expanse. At least, it indicates trends and provides a basis for further work and thought on the part of those interested in this question.

The statement is frequently made, and is in conformance with filtration theory, that the higher the flow rate through a filter, the lower the efficiency will be for the small particles (1.0 or 0.5 micron and less) which are trapped by diffusional and electrostatic forces rather than screening or impingement. This statement, to the best of our knowledge, is true, but it applies only to a given filter medium. It may not be true, in a quantitative sense, for one filter medium as compared with another. One factor deserving consideration is the fact that the chance of entrapment of a particle due to the random process of diffusion is proportional to the surface area of the filter fibers. Thus small fibers comprising a thick, dense filter medium of high specific surface (such as wool felt) will aid in collection of small particles by the mechanism of diffusion, and will permit higher gas velocities than could otherwise be tolerated.

Quite a variety of dense filters of various special and synthetic fibers have been made, which give quite exceptional efficiencies and which usually operate at low flow rates. The reverse-jet filter is to date, as far as we know, the only mechanism permitting the use of such a dense, fine-fibered filter on heavy dust loads where it is necessary to maintain the porosity of the filter, instead of throwing the filter away when it is plugged.

METHODS AND PROCEDURES

All effluent stack samples were taken by means of an isokinetic sampling head, usually at flow rates between 0.5 and 1.0 cfm, using Whatman No. 41 filter paper. Samples obtained were counted either in parallel plate alpha counters or in scintillation counters. With a few rare exceptions, at least three and frequently many more samples were taken, covering an appreciable operating period on the order of eight to twenty-four hours.

The amount of dust entering the filter was determined by weighing the collected dust. Where indicated, chemical analyses were performed on the collected dust to determine the Uranium content (or content of other alpha emitters), and the assumption was made that the effluent dust was of the same percentage composition as the entering dust. With few exceptions, this should be a fairly safe assumption for the products and processes involved. Thus the reported effluent concentration figures are calculated on the basis of total dust by weight from alpha activity determinations.

DISCUSSION OF RESULTS

The summary of test results reported on units in this study is tabulated in Table 1. It will be noted from the Performance Data columns that almost all of these units are operating under industrial, rather than laboratory, conditions. Effluent concentrations range from the order of 7×10^{-4} to 2×10^{-8} grains per cubic foot. Some of the lower concentrations are based on non-typical operations, or on a few number of samples; accordingly the average, with units 5a and 6 omitted, is 2.0×10^{-4} grains per cubic foot. Some of the values for Unit No. 7 have been omitted, for reasons that will be discussed. Average efficiency, on this basis, is 0.0135% passed, 99.986% retained.

Unit No. 7 in Table 1 is one duty that has been very troublesome. The dust which it is handling is known in the slang of the reverse-jet filter as a "seeper." In field experience with approximately 1000 reverse-jet filters on industrial applications, about a half-dozen "seepers" have been encountered. After considerable experimentation, the troubles with this unit were cured, or at least minimized, by the use of HCE-treated felt. From one point of view, the difficulties with Unit No. 7 in Table 1 is one duty that has been very troublesome. probably hold true for the general application are easier to determine on this Unit. The fact that the dust is a "seeper" gives larger effluent concentrations, and this plus the fact that the dust is radioactive makes effluent concentrations easier to assess.

Table II presents a history of the efficiency tests on Unit No. 7. It will be noted that with plain felt, collection efficiencies were on the order of 99.2%, and this was regarded as unsatisfactory. The average of all efficiency tests using resin treated and HCE felt was 99.946% as shown in Table 1 previously. Figure 1 shows a chronological plot of the history of Unit No. 7. Points labelled A and B are seriously questioned, although what back-checks are possible on the original data reveal no apparent error.

Sections of Figure 1, expanded, are plotted in Figure 2. For the resin-treated felt, 5 points form an almost perfect straight line when the time scale is logarithmic; and for HCE felt, 4 points form the same type of straight line. The resin-treated felt data covers a service period of from 1 to 20 days, and the HCE from 10 to 200 days. Since the lines have approximately the same slope, the increment in effluent concentration per day is approximately ten times greater for the resin-treated than for the HCE felt.

The straight lines obtained are very impressive when it is remembered that these various samples were taken over a year apart and by different persons; and that each point represents from 3 to 14 samples, over periods of 6 to 10 hours total sampling time for each point. Thus it is apparent why points A and B are puzzling; surely they cannot be the fault of randomness of the data. On the other hand, no other apparent factors affecting these results were observed, or at least recorded, and the answer is probably lost in history.

During the course of the experimenting with Unit No. 7, the data shown in Figure 3 were obtained. It is reasonable to assume that undisturbed felt should be a more efficient filter medium than felt which is "worked," by the blow-rings in order to maintain porosity. Although the notation in the figure shows blow-ring operation "normal" at the beginning of the test, this is open to question, as the data would suggest that the blow-rings were operating continuously rather than on pressure-switch actuation as would be really "normal." The ratio of the last two points on the curve is about 45/1 greater for continuous blow-ring operation than for non-operation. Presumably the same type of effect, although lesser in magnitude, would be noted with any dust.

SUMMARY

In the Uranium refining operations reported, the overall average effluent concentration from reverse-jet filters is 0.16 grains per 1000 cubic feet, representing 0.0135% passed or 99.986% retained.

One dust was found to be a "seeper", and as the result of experiment HCE felt is now being used on this filter. Detailed testing showed that effluent concentrations apparently first decrease, then increase in a logarithmic fashion with respect to time. The rate of increase in effluent for resin-treated felt was about 10 times that for HCE felt.

On the basis of a single series of tests, effluent concentrations were found to be as high as 45 times greater with continuous blow-ring operation than with no blow-ring operation. This effect is magnified in this instance but the same type of relationship probably is true for any dust. Thus it is postulated that pressure control operation should be more efficient than continuous operation, but there is no data to substantiate this point.

TABLE I

SUMMARY OF TEST RESULTS

UNIT	PERFORMANCE				EFFICIENCY							
	DUTY	FILTER RATIO CFM PER SQ. FT.	DIFF. PRESS INCHES W.G.	INPUT GRAINS PER CU. FT.	NO. SAMPLES	TOTAL SAMPLING TIME MINUTES	EFFLUENT GRS. PER 1000 CU. FT.			% PASSED	% RETAINED	REMARKS
							MIN.	MAX.	AVG.			
No. 1	LF-9 HANDLING	16.2	3-4	0.389	5	407	0.00277	0.0817	0.0380	0.00978	99.9902	LF-9 Basis
No. 2	QM-2 HANDLING	20.5	3-4	0.202	5	405	0.0161	0.0705	0.0469	0.0232	99.9768	QM-2 Basis
No. 3	(a) Q-11 and Other Feeds	34.2	6-7	1.89	11	325	0.023	0.735	0.286	0.0146	99.9854	Alpha Activity Basis-Actual Analysis
No. 3	(b) Q-11	27.7	6-7	32.4	2	20	0.200	0.622	0.411	0.00127	99.9987	Alpha Activity Basis-Theoretical Equilibrium
No. 4	QM-2 Final Filter Pneu. Conveyor	17.2	4-10	14.0*	7	321	0.294	0.645	0.380	0.00272	99.9973	QM-2 Basis
No. 5	(a) D22	18.3	3-4	0.00425	1	1440	--	--	17×10^{-6}	0.0004	99.9996	D22 Basis
No. 5	(b) D22	16.0	3-4	0.0456	6	360	0.00326	0.0415	0.0234	0.0515	99.9485	D22 Basis
No. 6	D22	17.5	3-4	0.0021	1	1425	--	--	0.0001	0.0048	99.9952	D22 Basis
No. 7	D20	21.3	3-4	0.418	63	12 Tests over 18 Mo.	0.0498	0.876	0.226	0.054	99.946	D20 Basis
						AVERAGE			0.16	0.0135	99.986	
						AVERAGE, 5A & 6 EXCLUDED			0.20	--	--	

TABLE II

HISTORY OF UNIT NO. 7

DATE	BAG TYPE	DAYS SERVICE (AVG.)	CFM PER SQ. FT.	ΔP INCHES W.G.	LOADING GRS/CU. FT.	EFFLUENT GRS/1000 CU. FT.	EFFICIENCY. %	NO. SAMPLES
10/18/50	Plain	110	19.6	2.5.-3.5	0.355	2.63	99.259	8
4/19/51	Type D	123	19.6	2.5-3.5	0.352	2.44	99.305	9
5/7/51	Resin	1	19.7	2.0	0.345	0.100	99.971	2
5/8/51	"	2	"	"	0.350	0.199	99.943	6
5/9/51	"	3	"	"	0.354	0.219	99.938	5
5/18/51	"	11	"	"	0.350	0.411	99.883	7
6/1/51	"	23	21.7	2.5-3.5	0.355	0.495	99.860	8
6/5/51	"	26	21.7	"	0.352	0.216	99.939	7
9/6/51	HCE	12	19.8	2.5-3.5	0.861	0.0498	99.994	4
9/27/51	"	20	"	"	0.500	0.109	99.978	3
9/28/51	"	21	"	"	0.391	0.102	99.974	3
2/20/52	"	158	20.3	2.5.-3.5	0.463	0.372	99.920	3
8/27/52	"	5	26.2	3.0-4.0	0.316	0.080	99.975	14
9/ 5/52	"	10	22.9	3.0-4.0	0.327	0.050	99.982	5

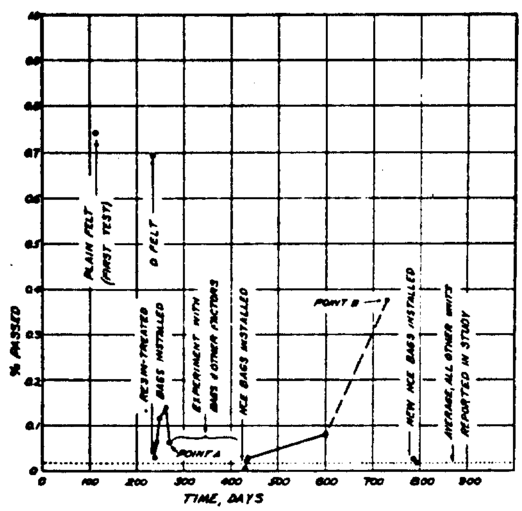

Fig. 1 — History of efficiency tests on unit no. 7.

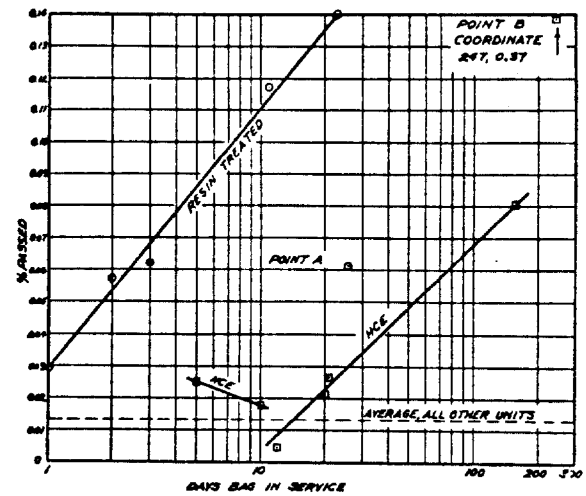

Fig. 2 — Variation of effluent with length of bag service for unit no. 7.

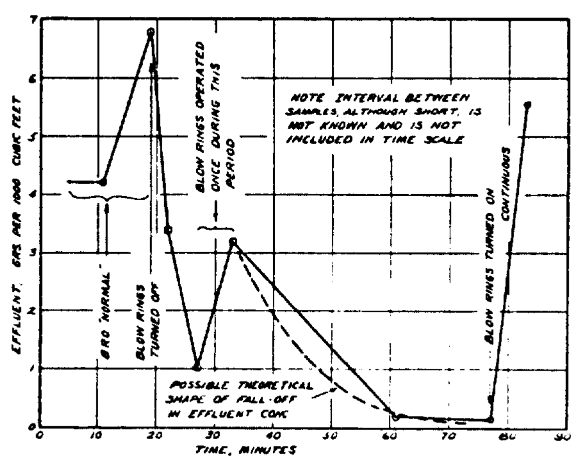

Fig. 3 — Variation of effluent with blow ring operation, unit no. 7 with plain felt.